

## FLOODS ON LOWER RIO GRANDE.

By ALFRED J. HENRY, Meteorologist.

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The great extension of irrigating works throughout the lower Rio Grande valley has made intensive agriculture possible in large portions of Starr, Hidalgo, and Cameron counties, Texas. The recent overflow of the river and the destruction of crops with very considerable damage to irrigating works has again drawn attention to the frequency of destructive floods in that part of the river basin.

The Rio Grande rises in the mountains of southwest Colorado at an altitude of more than 10,000 feet above sea level, flows in a general southeasterly direction for 1,800 miles and empties into the Gulf of Mexico at Brownsville, Tex. From its source to El Paso, Tex., a distance of 740 miles, the fall is 8,300 feet and from El Paso to the mouth—1,030 miles—the fall is 3,700 feet. In that section of the river below Laredo, Tex., the fall is much smaller and in the last 100 miles of its course is probably less than a foot per mile. The banks of the river at Laredo and thence upstream to El Paso are generally high—35–40 feet—and the river flows through a very sparsely settled region, hence the opportunity for damage by flood is very small. In the lower reaches of the stream the banks are only about half as high as at Laredo and while the normal flow is always well within its banks, yet, at times, the fluctuations of flow are very great.

The only tributary of consequence on the left bank is the Pecos River of Texas. On the right bank, however, the following-named streams join the main river below Presidio, Tex.—Conchos, Salado, and San Juan.

It so happens that tropical storms which strike the Gulf coast in the vicinity of the mouth of the Rio Grande generally dissipate in torrential rains over northern Mexico. Owing to the highly diversified topography and the sparseness of the vegetal cover on most of this region the run-off is very great and practically all of it comes from the right bank. There are two flood seasons, on the Rio Grande, viz, the late spring and early autumn. The first comes generally in May, when the run-off from melting snow reaches its maximum. Heavy rainfall over the watershed in southern Colorado and New Mexico is quite apt to cause floods in the river in those States notwithstanding the fact that considerable flow is diverted for irrigation. A serious flood in the lower river is rarely caused by an up-stream flood unless heavy rain should fall in the lower watershed concurrently with rains in west Texas and New Mexico. The autumn flood is confined almost wholly to the lower river and may be considered as the major flood of the year. It is an aftermath of the tropical storms or West Indian hurricanes which occasionally strike the coast in the vicinity of the mouth of the Rio Grande as above stated.

There are no bridges across the Rio Grande below Laredo and no permanent object upon which to install a river gage, hence it has been with the greatest difficulty that a river gage has been maintained for any length of time at the points where overflow takes place. Continuous gagings have been made at Rio Grande City, Tex., for a period of but 6 years. Unofficial information gleaned mainly from press dispatches and unpublished manuscript

reports from the flooded regions enables us to list the destructive floods in the lower Rio Grande in the following paragraphs:

## SPRING FLOODS.

*June, 1903, flood.*—A level of 19.5 feet said to have been reached at Roma, Tex., and a rise of 15 feet occurred at Fort Ringgold (Rio Grande City).

*May, 1905, flood.*—This flood was confined to the upper reaches of the stream in New Mexico and extreme west Texas.

## AUTUMN FLOODS.

*September–October, 1904, flood.*—This flood was due to heavy rains over the watershed in New Mexico and also over the greater portion of the Rio Grande Valley in Texas, especially in September. At Rio Grande City, Tex., the river overflowed its banks from September 16 to 22, resulting in the complete destruction of all crops planted along the river valley and a number of small shacks or huts \* \* \*.

*August, 1909, flood.*—This storm caused high tides on the coast of Texas and considerable damage by wind and water in the lower coast country. At Corpus Christi a wind velocity of 56 miles per hour was recorded on the 27th of August. The attending precipitation was exceptionally heavy, especially in northern Mexico, where it inundated the country, causing much loss of life and property and much suffering. The lower Rio Grande rose higher than known for years and flooded the lowlands for miles, resulting in an interruption of traffic and communication and doing other damage. At the close of the month the river had begun to recede at Sam Fordyce, but continued at high-water mark below that place.

*September, 1910, flood.*—Mission, Tex.—On September 14, 5.65 inches of rain fell at Mission in 24 consecutive hours, and between Mission and Brownsville the rainfall for the corresponding period was much heavier. The river reached flood stage on the morning of September 19, when it was 26 feet 10 inches above the lowest known water this year. There being no river gage it was difficult to ascertain how this year's flood compares with that last year, but from those who have been close observers of the river for many years it is learned that the high water of 1909 exceeded that of this year by about 4 feet.

*September, 1919, flood.*—This flood was due to heavy rains that fell in connection with the tropical storm of September 14–16. The rise at Eagle Pass, Tex., amounted to 27.2 feet in 24 hours on September 16. This rise was followed by a second period of rains and a second flood wave on the 22d, though not so severe as the first. Below Eagle Pass there was but a single crest of 26.2 feet on the Rio Grande City gage on September 26. For additional information respecting this flood see this REVIEW.

The highest stage of record at Rio Grande City, Tex., is 31.2 feet in 1872. Details of this flood are lacking.

Following is a statement of the highest stages each year compiled from various sources for the earlier years and from the regular observations as indicated:

(The flood stage is 15 feet.)

Year.	Month.	Highest stage.	Authority.
1872..	August.....	31.5	Local reports.
1892..	August.....	20.2	United States Weather Bureau.
1893..	.....	.....	No flood.
1903..	June.....	21.0	Estimated on rise at Roma just above Rio Grande.
1904..	October.....	30.0	Estimated on rise at Fort Ringgold.
1909..	August.....	30.0	Estimated.
1910..	September.....	26.0	Do.
1913..	October.....	28.0	United States Weather Bureau.
1914..	October.....	25.5	Do.
1915..	September.....	16.8	Do.
1916..	September.....	20.8	Do.
1917..	October.....	21.7	Do.
1918..	May.....	23.5	Do.
1919..	September.....	26.2	Do.

## FLOOD WARNINGS IN NEW ZEALAND.

The problem of flood prevention in New Zealand is dealt with in a recent report by the dominion meteorologist, Lieut.-Col. D. C. Bates, to whom we are indebted for the following notes. The interference of civilization with natural conditions is not usually in the direction of lessening flood damage, clearing and drainage, causing the water to run off quickly, thus increasing the scouring of slopes and deposition of silt in the lower reaches. The effect is to raise the general level of the lower beds and aggravate flooding. The problem of prevention is one which appears only to be soluble as a national task, the reconciliation of conflicting interests being too difficult to achieve on any other lines and the report recommends strongly the organization of both prevention and warnings on a proper basis.

Attention is directed to the abnormal flooding which not infrequently occurs when the winter snows melt, these being entirely disproportionate to the actual amount of precipitation. Apart from snow the run-off is stated to be approximately 25 per cent of the precipitation, a figure which we imagine must be applied only with a very generous margin of uncertainty. Experience in the British Isles shows us that the expression of the run-off as a percentage of the amount of precipitation is misleading, since quite apart from the very great variability at different seasons and under different conditions of soil and weather, recognized by Mr. Bates, it is practically certain that a much larger proportion of run-off occurs when the average rainfall is large than when it is small.

The prediction of floods may be attempted on (a) the weather chart; (b) the records of rainfall in the river basins, and (c) the actual rise of the streams in their upper reaches. Owing to the known uncertainty, especially in respect to locality, in forecasting heavy rain, the first mentioned method is only applicable in a general manner. The second source of information is undoubtedly capable of development by provision of more observing stations and improving means of communicating records, but the actual rising of the river affords the most certain and striking means of forecast, not only for the time but for the height of an inundation.

The report recommends the closer observation of rainfall, the establishment of flood gages, and the formation of a committee of safety or rivers board charged with the organization and administration of flood warnings in consultation with the dominion meteorological service, the public works, and railway departments.—Symons's Meteorological Magazine, Oct., 1919, p. 101.

## PRECIPITATION AND RUN-OFF IN THE DRAINAGE BASIN OF THE ODER.

By KARL FISCHER.

[Abstracted from Yearbook of Hydrology of North Germany, Special Communication, Vol. 3, No. 2.]

Records of precipitation and run-off for eleven subdivisions of the Oder drainage basin were maintained for the most part during the period 1896 to 1905. Stream discharges were determined from rating curves based on current-meter measurements. Rainfall records for the determination of the mean precipitation on each area were presumably numerous and complete, but are not given. Records of precipitation and run-off, either annual or monthly, are not given in complete form, but only in the form of averages for five-year periods and for the complete records.

The most important results, perhaps, are the general averages for the different streams which are summarized in the accompanying tabulation. Plotting rainfall against yield, the author finds an approximately linear relation, which holds however, only in a general way for the different subdivisions of the Oder Basin. The author expresses these relations by means of formulas of the linear type used by Penck—

$$\begin{aligned} y &= 0.702p - 260.5 \text{ year,} \\ y' &= 1.167p' - 181 \text{ winter,} \\ y'' &= 0.512p'' - 118 \text{ summer,} \end{aligned}$$

in which  $y$  is the yield of the drainage basin in millimeters and  $p$  the precipitation in millimeters.

These formulas are intended to apply only to the average yield of subdivisions of the Oder basin and not to the yield of any given subdivision in different years.

There are several exceptions which are discussed by the author. Transposing the formulas so as to express water losses in terms of precipitation, the author finds that the water losses decrease as the precipitation increases for the winter season, but water losses increase with precipitation both for the summer season and for the year as a whole.

The paper is accompanied by numerous tables and diagrams, among which may be specially noted hydrographs of monthly precipitation, yield, and water losses at each gaging station. These hydrographs are in general very similar, showing in nearly all cases a minimum of precipitation in January and maximum in July, a maximum of yield in April, and a maximum of water losses in July, and a minimum of water losses in February or March.

Summary of Karl Fischer's gagings in the Oder drainage basin, 1896-1905.

[P=Precipitation in mm. Y=Yield in mm. L=Water losses in mm. Winter=Nov.-Apr. Summer=May-Oct.]

Stream and location.	Drainage area (square kilometers).	Winter.			Summer.			Year.		
		P'.	Y'.	L'.	P''.	Y''.	L''.	P.	Y.	L.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1. Oder at Ratibor.....	6,737	285	180	125	551	151	400	836	311	526
2. Malapane.....	2,037	292	137	155	435	112	323	727	249	478
3. Glacial Netz.....	5,534	263	137	126	496	131	365	759	268	491
4. Bohner.....	5,938	282	155	127	438	132	308	730	287	433
5. Lansitz Netz.....	4,232	298	134	164	451	102	349	749	236	513
6. Mountain areas 1+3+4+5.	21,441	282	148	134	489	132	356	770	280	490
7. Warthe, at Posen.....	24,820	221	73	148	337	46	291	553	119	439
8. Netz, at Vordamm.....	15,872	216	74	142	321	54	267	537	128	409
9. Warthe, at Landsberg.....	51,893	216	71	145	326	49	277	542	120	422
10. Oder, at Steinau.....	29,878	254	115	139	460	104	356	714	219	495
11. Oder, at Pollenzig.....	47,293	250	97	153	427	85	342	677	182	495
12. Oder, at Hohenaathen....	106,564	233	81	152	375	65	310	608	146	462